4.0 PROJECT DESCRIPTION OF APPLICANT'S PROPOSED ACTION

The proposed Wind Park will consist of 130 Wind Turbine Generators (WTGs) located at Cape Wind's Proposed Site location on Horseshoe Shoal in Nantucket Sound, Figure 4-1. The WTGs will be arranged to maximize the Wind Park's energy generating capacity in order to achieve a maximum potential electric output of 454 MW. The wind-generated electricity from each of the turbines will be transmitted via a 33 kV submarine transmission cable system to the Electric Service Platform (ESP) centrally located within the WTG array. The ESP will then take the wind-generated energy from each of the WTGs and transform and transmit this electric power to the Cape Cod mainland via two 115 kV alternating current (AC) submarine cable circuits. These submarine cable systems will make landfall in the Town of Yarmouth. From this landfall, an upland transmission system will be installed in an underground conduit system within existing roadways and right-of-way (ROW) where it will intersect with the existing NSTAR Electric ROW near Willow Street in Yarmouth. The upland transmission line will continue within the ROW to the Barnstable Switching Station. The Project's interconnection with the existing NSTAR Electric transmission line will allow wind-generated energy from the WTGs to be transmitted and distributed to users connected to the New England transmission system including users on Cape Cod and the Islands. These areas in their entirety constitute the Project area.

Construction and operation of the proposed Project will not preclude or prohibit traditional uses of the watersheet area within or around the Wind Park turbine array (see Section 5.12). Use of the watersheet area within the turbine array would include general commercial and recreational navigation, commercial and recreational aviation, commercial and recreational fishing, and other traditional water-based activities that promote the use and enjoyment of this area of Nantucket Sound.

4.1 Description of the Wind Park

The location and orientation of the WTG array was established using WTG design and wind power performance data specific for the Horseshoe Shoal location. The number of WTG units in the array are a function of the energy generation capacity of each WTG (3.6 MW±) multiplied by the desired installation capacity of 468 MW to produce a combined maximum energy generating capacity of approximately 454 MW after consideration of inherent energy losses within the system. The orientation of the WTG array was established as a result of a wind power density analysis conducted by the Applicant to determine maximum potential wind generating capacity at Horseshoe Shoal. The WTG array configuration shown in Figure 4-2 represents a technically efficient and economically feasible array for the Project in order to meet the desired energy generating capacity and the continuation of existing watersheet use (commercial and recreational fishing, boating, etc.) and present uses of the seabed. The potential for sand and gravel or other mineral resource extraction within the project area prior to decommissioning would be reduced due to the presence of the buried inner-array cables.

As previously stated, the Project is designed for a maximum delivered electrical energy capacity of 454 MW, which will be connected to the existing NSTAR electric transmission system servicing Cape Cod and the New England region. This generating capacity is based on the design wind velocity of 30 mph (14 m/sec) and greater, up to the maximum operational velocity of 55 mph (25 m/sec). Based on the average wind speed of 19 mph (8.89 m/sec), the net energy production delivered to the regional transmission grid will be approximately 1,489,200 MW hours/year.

The WTGs will be arranged in specific parallel rows with appropriate spacing to obtain an optimal energy-generating arrangement. The WTG array will be located outside of the Massachusetts 3-mile state jurisdictional limit within the waters of Nantucket Sound subject to federal oversight and control. As shown in Figure 4-1, the northernmost WTGs will be approximately 4.7 miles (7.6 km) from the nearest point of land on the mainland (Point Gammon), the southeastern portion of the Wind Park will be approximately 13.8 miles (22.2 km) from Nantucket Island, and the westernmost WTGs will be approximately 9.3 miles (15.0 km) from the Island of Martha's Vineyard (Oak Bluffs). The spacing between the WTGs within the array is 0.34 nautical mile (629 meters) by 0.54 nautical mile (1,000 meters) between each WTG.

4.1.1 Wind Turbine Generators (WTGs)

The Project will utilize pitch-regulated upwind WTGs with active yaw and a three-blade rotor (see Figure 4-3 and Figure 4-4). The WTG nacelle hub height will be approximately 246 feet (75 meters) from the Mean Low Lower Water (MLLW) datum (0.0 feet = MLLW). The main components of the WTG are the rotor, the transmission system, the generator, the yaw system, and the control and electrical systems, which are located within the WTGs nacelle. The WTGs nacelle will be mounted on a manufactured steel tower supported by a monopile foundation system. This main support tower will have a base diameter of approximately 16.75 feet and 18 feet (5.1-5.5 meters) at the MLLW datum plane (depending upon water depth). At the base of the tower, a pre-fabricated access platform and service vessel landing (approximately 32 feet (9.6 meters) from MLLW) will be provided. Design criteria for the turbine and foundation system include the hurricane criteria as indicated in the Massachusetts Building Codes. The steel tower and nacelle will be mounted on a welded steel monopile foundation as described in more detail below.

4.1.1.1 Nacelle

The nacelle is the portion of the WTG that encompasses the drive train and supporting electromotive generating systems that produce the wind-generated energy. For offshore applications, the nacelle is specially designed to seal the interior from salt spray and moisture while providing controlled environmental conditions for its working components. The nacelle includes maintenance cranes, access hatches, and also has wind sensors located on its peak. An illustrative drawing of a typical WTG nacelle is shown in Figure 4-5.

4.1.1.2 Rotor

The WTG rotor has three blades manufactured from fiberglass-reinforced epoxy, mounted on the hub. The rotors will have an overall tip to tip diameter of approximately 341 feet (104 meters). The rotor blades are pitch-regulated to continually control their pitch angle to the wind in order to optimize wind energy production with minimal noise. The blades will be pitched to prevent rotation when wind speed exceeds 55 mph (25 m/sec) and will also engage the disc brake system to positively lock the rotor. Each blade is protected against potential damage from lightning strikes by copper plates mounted in the blade tips and a grounding wire brought back to the rotor and connected to the tower by carbon brushes. This establishes a proper ground connection and will dissipate any lightning strikes. Temporary icing of a rotor blade would activate vibration sensors causing turbine shutdown in order to prevent rotor damage or hazard from flying ice.

4.1.1.3 Tower

A manufactured tubular conical steel tower with triple paint system supports the WTG nacelle. This tower will have internal access ladders and platforms providing access to the nacelle. The tower will be designed to meet all relevant codes and standards associated with site-specific wind loads, earthquake loads, sea-state conditions, and other loading conditions. There are various auxiliary structures such as access platforms, ladders, and boat docking structures attached to the tower to allow service vessels to transfer technicians and equipment for routine maintenance of the WTGs. The tower is accessed from the platform by a galvanized steel hatch door. Access to the platform is from the boat ladder through the lockable hatch.

Each of the individual WTGs will be lighted by two flashing red lights on top of the nacelle (approximate height of 260 feet (79 meters) above MLLW) and two flashing amber lights on the lower access platform (approximate height of 35 feet (10.7 meters) above MLLW). Lights will vary in intensity depending on the specific location of the individual turbine, with perimeter WTGs lighted at a higher intensity than those located within the interior of the wind farm (see Section 5.12 of DEIS).

4.1.1.4 Marine Use Design

The WTGs have been specially designed for the offshore marine environment and include a number of special features that are not found on land based WTGs. Some of the items that support the marine usage of the proposed WTGs are as follows:

- Air tight tower and nacelle;

- De-humidifying system;
- Heat-exchanger cooling system for gear box and generator;
- Offshore corrosion protection; and
- Permanent crane in nacelle for smaller components.

4.1.1.5 Life Span

The WTGs have a design life span of twenty years, although such estimates are conservative and based on design turbulence and wave conditions. By incorporating good maintenance and ongoing inspections, the life span of the equipment can be significantly extended.

The design is based on an operating prototype[69] that has gone through a rigorous design review. The design criteria are based on smaller turbine operating experience that has been scaled up. The blades, or airfoils, have gone through a dynamic destructive testing process similar to commercial aircraft wings to validate the structural integrity. The towers and piles include conservative design criteria and a liberal corrosion allowance.

Coatings have been carefully selected to provide protection from the marine environment and to maximize coating life.

4.1.2 Configuration of WTGs

In order to generate maximum wind energy production, the WTGs will be arranged in specific parallel rows in a grid pattern to obtain an optimal energy-generating arrangement. For this area of Nantucket Sound, the wind power density analysis conducted by the Applicant determined that orientation of the array in a northwest to southeast alignment provides optimal wind energy potential for the WTGs. This alignment will position the WTGs perpendicular to prevailing winds, which are generally from the northwest in the winter and from the southwest in the summer for this geographic area of Nantucket Sound. The WTGs will have a computer-controlled yaw system that ensures that the nacelle is always turned into the wind and perpendicular to the rotor. In addition to maximizing potential wind energy production, the WTGs must also be sufficiently spaced within the array in order to minimize power losses due to wind shear and turbulence caused by other WTGs within the array.

Other technical and economic siting criteria were established for the array design that factored into the development of the proposed WTG configuration. These include:

- Water depth criteria: a minimum water depth of 12 feet (3.6 meters) MLLW and a maximum water depth of 50 feet (15.2 meters) MLLW was established as the design criteria necessary to properly address construction techniques and pile design and cost considerations. The minimum water depth of 12 feet (3.6 meters) was established based upon the vessel size required for installation of the turbines and the maximum water depth was established based upon design fatigue load. Please refer to Appendix 3-B for more details on the hydrodynamic effects on offshore wind turbine support structures.
- Energy loss criteria: minimize energy losses for WTGs located within the array due to lower mean wind speeds in the wakes of upstream WTGs. By installing several WTGs in an array, each WTG will generate a wake that will affect the output from other downstream WTGs in the Wind Park.
- Maximize spacing to allow existing watersheet uses to continue.
- Minimize mechanical fatigue loads on the WTG and support tower: develop inner-array spacing of the WTGs that minimizes mechanical turbulent wakes of upstream WTGs.
- Minimize energy transmission losses: develop inner-array spacing that minimizes the amount of inner-array submarine cabling to maintain maximum energy transfer to the ESP, and minimize energy losses due to cabling lengths.

[69] A prototype of the GE 3.6 MW WTG is presently undergoing testing at an upland site in Barrax, Spain. The prototype WTG has been operational for over 1,000 hours. Testing has included a complete acoustical noise measurement program over the full operating range and performance testing to verify power versus wind speed. All testing was done in accordance with relevant IEC standards. The prototype WTG has a 50 hertz generator as compared to the 60 hertz generator required for the Cape Wind project. Seven additional GE 3.6 MW WTGs are in service at the Arklow project in the Irish Sea and thirty additional units are planned for the Gunfleet Sands project of the coast of Great Britain. These are commercial units and not prototypes.

As a result of the wind energy production performance analysis for this geographic area of Nantucket Sound, including the WTG configuration and performance criteria cited above, it was determined that the optimal WTG spacing within the array is 0.34 nautical mile (629 meters) by 0.54 nautical mile (1,000 meters) between each WTG.

4.1.3 Foundation System Design

4.1.3.1 Introduction

Alternative foundation system designs for the WTGs were carefully considered for the Project specific to required design loads, structural stability, and minimization of seabed disturbance during construction. The foundation system is a major and fundamental component of the WTG that is used to keep the nacelle in its proper position while being exposed to the forces from wind and sea-state effects on the WTG rotor and the nacelle support structure.

The foundation systems that are utilized to provide structural support for existing offshore wind turbines are generally of two design types (with several structural variations of each to meet site specific conditions, see Figure 4-6). The designs are either gravity base foundation systems, which utilize a pre-fabricated large diameter concrete and steel caisson placed on the seabed to support the WTG, or monopile foundations, which are either pre-fabricated steel or concrete pile systems driven or augered into the seabed. These foundation types are not necessarily interchangeable and are primarily dependent upon site-specific geological conditions of the seabed.

The gravity foundation has been utilized for several of the existing offshore European WTG installations that have bottom characteristics that preclude the use of monopiles (e.g. ledge, rocks or soil characteristics unsuitable for piles). Experience has shown that they are not suitable for the larger offshore wind farms (as evidenced by the limited number of European projects utilizing or planning to use the design (see Appendix 3-F)) and would require a shipyard and dry dock near the site to construct and allow the massive foundation structures to be floated out to the site and sunk. The gravity foundation design also presents a much greater environmental impact than a monopile due to the large diameter (approximately 60 feet (18.3 meters)). The Middelgrudden wind farm in Denmark represents the largest gravity foundation utilized which is on a 2 MW WTG.

The monopile foundation system design represents the most suitable and preferred foundation solution for offshore applications. This type of foundation design system is the predominant system type presently utilized for offshore WTGs. The monopile is simply a large diameter pile (16.75 to 18 feet (5.1 to 5.5 meters)) driven 50 to 90 feet (15.2 to 27.4 meters) into the seabed depending on the local load bearing characteristics of subsurface marine sediments. The monopile is open-ended, allowing sediment to be encased within the monopile to provide for additional structural support. As with any foundation, monopiles must be carefully designed from a detailed analysis of the site-specific geotechnical and physical exposure conditions. One of the most significant challenges associated with the use of a monopile is the limited commercial availability of facilities that can fabricate large enough structures due to the significant weight and sizes required. As the water depths and loads increase the pile diameter and thickness must increase as well.

The tripod structure, a variation on the standard monopile foundation, is being evaluated by the industry for future generations of deeper water WTG's. This conceptual design provides a very stiff foundation system, and is governed by the fatigue loading and the high stress concentrations inherent to welded tubular joints. Some of the design issues are beyond the current state of the art of the wind industry and are not commercially available at this time.

The monopile-type foundation system represents the most commonly used design solution in conventional offshore installations, and is a well-proven structural foundation type for offshore applications. This foundation system requires adequate subsurface soil conditions to provide appropriate structural stability and load bearing capacity. The pile is driven to the design depth into the seabed by means of a drop-hammer (mechanical) installation process. This type of foundation system allows the lateral and axial loading forces of the WTG to be transferred to the seabed. It also represents the foundation type system that is the easiest to install and results in the least amount of seabed disturbance. Minimal disturbance of sand and sediment will take place by pile driving activities. The piles are hollow and will contain bottom material that is displaced in the pile. Therefore, installation of the monopile foundation will not require excavation or backfill of bottom sediments.

After careful technical and economic evaluations of foundation types, the Applicant has proposed a monopile-type foundation system for the Project.

4.1.3.2 Monopile

Based upon preliminary geotechnical and structural engineering evaluations, the monopiles that will be located within the Project Area will utilize two different diameter foundation types depending on water depth. Water depths between 0-40 feet (0-12.2 meters) will utilize a 16.75 foot (5.1 meter) diameter monopile and water depths between 40-50 feet (12.2-15.2 meters) will utilize a 18.0 foot (5.5 meter) diameter monopile. The monopiles will be driven approximately 85 feet (26 meters) into the seabed at Horseshoe Shoal to provide adequate structural support for the WTG support tower and the nacelle. The monopile foundation structure provides an added benefit of a more flexible foundation design compared to a gravity base foundation system. The monopile foundation design provides aerodynamic damping capabilities to increase the WTG's design life. The aerodynamic damping capability results in a design that offers considerably reduced fatigue from aerodynamic loading compared to more rigid foundation types.

4.1.3.3 Foundation System Design Criteria

Based on the results of the extensive geophysical and geological surveys and geotechnical subsurface soil conditions at Horseshoe Shoal, the use of a driven monopile was chosen as the preferred foundation design system for the WTG.

In addition, the selected pile foundation system was analyzed for the following structural loadings, which are both steady state and dynamic in nature.

- Wind loads from WTG operation including wind shear and turbulence;
- Hydrodynamic loads from prevailing and extreme sea-state conditions;
- Impact loads from pile-driving installation;
- Earthquake loads according to the Massachusetts State Building Code; and
- Lateral loading from sea ice.

Geophysical and geotechnical surveys indicate that subsurface soil conditions within the WTG array on Horseshoe Shoal consist primarily of sands and glacial till deposits to greater than 100 feet (30.5 meters) below the present bottom. These soil conditions are preferred for pile foundation systems due to their natural load bearing capacity, particularly for cantilever-design systems. The pile foundation system will likely be installed by mechanical hammer driving, thereby minimizing seabed disturbance and turbidity associated with foundation installation.

The significant wave height and period for various water depths was calculated and utilized in the foundation design evaluation. This analysis showed that the dominating loading criterion for monopiles is the fatigue loading. For structural analysis the fatigue loading from the wind is combined with a representative fatigue wave. A design tidal current of 1 meter per second (m/sec) was applied to the design analysis based on data obtained by baseline studies performed by Woods Hole Group (see Appendix 5.2-A). The soil conditions in the area are best characterized as glacial drift, overlaying coastal plain deposits. The glacial drift is found to be mainly sand material.

Although foundation loading by drifting sea ice is not a frequent occurrence for this area of Nantucket Sound, a conservative ice loading design factor of a 6-inch ice cap was applied in the analysis. In addition, a 1.18-inch ice cover over the tower and nacelle was included.

After installation of the pile foundation, some localized scour around the monopile foundation may occur depending on the location of the WTG on Horseshoe Shoal and local sediment transport conditions. Scour protection will be installed and designed using scour mats[70]. (Refer to Appendix 4.0-A, Scour Analysis). Several options were considered, however, it was determined that the use of synthetic fronds designed to mimic seafloor vegetation would afford the necessary scour protection while minimizing potential alterations to the benthic and fish communities typically associated with Horseshoe Shoal. This is because the synthetic fronds (scour control mats), when secured to the bottom as a network, trap sediments and become buried. This scour protection approach is more consistent with the low bottom relief of Horseshoe Shoal than traditional boulder revetment and is expected to result in little net change over time from the existing bottom conditions, both in terms of geology and biological community. The first installations of scour control frond systems were made in the Southern North Sea for Shell Exploration & Production in 1984 to protect scoured pipelines in shallow water and these systems remain in place and have compacted sediment banks formed over them to this day. As described in Appendix 4.0-A the mats are made of buoyant polypropylene fronds and polyester webbing which is anchored securely to the seabed. Independent tests by Shell Chemical have found the fronds to be chemically inactive and biologically inert. The mats do not breakdown in seawater over time and are fully U.V. stabilized and once installed underwater are unaffected by U.V light. In the event that scour mats are found to be less effective than anticipated, more traditional scour protection methods (such as rip-rap) are available as an alternative.

The Massachusetts State Building Code describes Nantucket Sound as a low seismic activity area. Therefore, seismic loading considerations were not a determining factor in the foundation design analysis.

The monopile will have a three-part system to protect it from corrosion. This will consist of the following:

- Corrosion allowance – a liberal corrosion allowance will be added to the design criteria;
- Coating - A coating system will be applied to surfaces that come in contact with seawater, including the splash zone; and
- Cathodic protection utilizing sacrificial anodes (pure aluminum).

Experience with steel structures has shown that this combination is the best way to protect the splash zone of the structure against corrosion.

4.1.3.4 Maintenance and Service Access to the WTG

Each WTG will require facilities for service vessel and maintenance personnel access at or near the water level of the foundation system and tower. As shown in Figures 4-3 and 4-4, the WTG access facilities will consist of a tubular metal post system and access platform designed to accommodate the bow of the service vessel as well as an access ladder to the WTG tower.

Each WTG will have two of these structures; each will be located on the leeward side of the structure corresponding to the winter and summer prevailing wind directions. The ladders will terminate at the access platform and will have a lockable hatch for security.

Service vessels will dock on the leeward side of the pile, and allow service personnel to step onto the ladder and climb up to the platform. Maintenance personnel can then enter the inside of the WTG tower for access to the nacelle.

4.1.4 Electrical Service Platform (ESP)

An ESP will be required to be installed and maintained within the approximate center of the WTG array. The ESP will serve as the common interconnection point for all of the WTGs within the array. Each WTG will interconnect with the ESP via a 33 kV submarine cable system. These cable systems will interconnect with circuit breakers and transformers located on the ESP in order to transmit wind-generated power through the 115 kV shore-connected submarine cable system. The two 115 kV submarine circuits will then ultimately connect to the existing land-based NSTAR Electric transmission system on Cape Cod.

[70] Test scour mats were installed at the Cape Wind SMDS in the Fall of 2003 and found to be operating as expected when visually inspected by divers in June 2004 (see Section 5.2)

The ESP will provide electrical protection and inner-array cable sectionalizing capability in the form of circuit breakers. It will also include voltage step-up transformers to step the 33 kV inner-array transmission voltage up to the 115 kV voltage level for the submarine cable connection to the land-based system. The service platform will also function as a helipad and as a maintenance area during periods of servicing the Wind Park equipment.

As shown in Figure 4-7, the ESP will be a fixed template type platform consisting of a jacket frame with six 42-inch (106.7 centimeters) driven piles to anchor the platform to the ocean floor. The platform will consist of a steel superstructure of approximately 100 feet by 200 feet (30.5 meters by 61 meters). The platform will be placed approximately 39 feet (12 meters) above the MLLW datum plane in 28 feet (8.5 meters) of water.

The ESP will include cable-spreading with insulated circuit breakers to protect the 33 kV system. The 33 kV circuit breakers will be arranged in four switchgear line-ups, each of which will connect to one of four transformers to increase the voltage level to 115 kV for transmission to shore. The high voltage system on the ESP will include 115 kV insulated switchgear for protection and will be connected to two 115 kV submarine transmission cable systems. Operation will be automated and remotely controlled via the electronic supervisory control and data acquisition system (SCADA). Additionally, the ESP will house the hub for the SCADA link between the WTGs and the Project's shore-based control systems.

In addition to the electrical equipment, the ESP will include fire protection, emergency backup generators, and other ancillary systems. These systems will include ventilation, safety, communications, temporary living accommodations and required systems. The living accommodations are for emergency periods when crews cannot be removed due to weather issues. These accommodations will utilize waste storage holding tanks that will be pumped to the service vessel for proper disposal. All equipment will be contained within an enclosed weather-protected service area.

Maintenance and service access to the ESP will normally be by service boat. A boat landing dock consisting of a fender structure with ladder is attached to the ESP to allow boat landing and transfer of personnel and equipment and temporary docking of the service craft. The ESP will have a helicopter deck to allow personnel access when conditions preclude marine transport, and for emergency evacuation. Equipment and material transfer will be by a crane mounted on the ESP.

4.1.5 Inner-Array Cables

Each of the 130 WTGs within the Wind Park will generate electricity independently of each other. Within the nacelle of each turbine, a wind-driven generator will produce low voltage electricity, which will be "stepped up" by an adjacent transformer to produce the 33 kV electric transmission capacity of the WTG. Solid dielectric submarine cables from each WTG will interconnect within the grid and terminate at their spread junctions on the ESP.

The submarine cable system interconnecting the WTGs with the ESP will be of solid dielectric AC construction, using a three-conductor cable with all phases under a common jacket. The cables will be arranged in strings, each of which will connect up to approximately 10 WTGs to a 33 kV circuit breaker on the ESP (Figure 4-8). The electrical current in the cable segments within each string will vary depending on WTG's location within the string. Cable segments closer to the ESP will provide greater transmission capacity compared to cables further away from the ESP. It is anticipated that three different cable sizes (150 mm2, 400 mm2, and 600 mm2) will be used to accommodate this variation in transmission capacity related to the distance of the WTG from the ESP.

The inner-array cables will consist of solid dielectric AC cable specifically designed for installation in the marine environment. These types of cables do not require pressurized dielectric fluid circulation for insulating or cooling purposes. Each cable will consist of three copper conductors (extruded cross-linked polyethylene (XLPE) insulation and lead sheathed) plus an interstitial fiber optic cable equipped with 24 single mode ITU-T G.652 fibers. The entire cable assembly will be wound and protected by a single layer of galvanized steel wire armor and an outer sheathing of polypropylene strings. See Figure 4-9.

The conductor cross sections are 3x150 mm2, 3x400 mm2, and 3x600 mm2 and the overall diameter of the cable is 132 mm (5.19 inches), 146 mm (5.75 inches), and 164 mm (6.45 inches) respectively.

4.2 Description of the Proposed Transmission Facilities

From the centrally located ESP within the Wind Park, the wind-generated energy from each of the WTGs will be transformed to the voltage of 115 kV. Two 115 kV AC submarine transmission circuits will bring the electric energy from the ESP to the mainland, a distance of approximately 12.2 miles (19.6 km). These submarine transmission lines will make landfall at the proposed location at the end of New Hampshire Avenue in the Town of Yarmouth. From this landfall, an upland 115 kV transmission line will be installed in an underground conduit system within existing roadways for approximately 4.0 miles (6.4 km) until it intersects the existing NSTAR Electric transmission line ROW at Willow Street in Yarmouth. From that point, the upland transmission line will proceed west and then south in an underground conduit system approximately 1.9 miles (3.1 km) along the existing NSTAR Electric ROW to the Barnstable Switching Station. The interconnection with the existing NSTAR Electric transmission system will allow wind-generated renewable energy from the WTGs to be distributed to consumers connected to the New England transmission grid, including consumers on Cape Cod and the Islands of Martha's Vineyard and Nantucket.

The proposed electrical interconnect facility on the proposed route will be two 115 kV solid dielectric submarine transmission lines and two 115 kV solid dielectric upland transmission lines. The submarine transmission lines will be jet plowed below the seabed and the upland transmission lines will be encased in an underground concrete transmission ductbank.

4.2.1 Submarine 115 kV Transmission Cable System

Two 115 kV submarine transmission circuits will interconnect the ESP with the existing NSTAR Electric transmission grid serving Cape Cod. Two AC circuits are necessary to provide the required electric transmission capacity from the Wind Park when operating at high capacity to the NSTAR Electric transmission system and to provide increased reliability and redundancy in the event of a circuit outage. Each circuit consists of two (2) three-conductor cables, resulting in a total of four (4) cables. The four, three-conductor cables offer several other advantages including integral fiber optic cables and increased reliability in the case of an internal fault in one cable, where more than 75% of the total power available could still be delivered while the faulted cable is awaiting repair.

The submarine transmission line will consist of solid dielectric AC cable specifically designed for installation in the marine environment. These types of cables do not require pressurized dielectric fluid circulation for insulating or cooling purposes. Each cable will consist of three 800 mm2 (approximately 1,600 kcmil) copper conductors, XLPE insulated to 123 kV and lead/PE sheathed, plus an interstitial fiber optic cable equipped with 24 single mode ITU-T G.652 fibers. The entire cable assembly will be wound and protected by a single layer of galvanized steel wire armor and an outer sheathing of polypropylene strings. See Figure 4-10.

The four submarine transmission cables will be installed as two circuits by bundling two cables per circuit together during installation and installing the two circuits. The conductor cross section is 3x800mm2 (approximately 3x1,600 kcmil) and the overall diameter of the cable is 197 mm (7.75 inches).

4.2.2 Upland 115 kV Transmission Cable System

Once the 115 kV submarine transmission lines make landfall at the proposed location of New Hampshire Avenue, the transmission lines will be interconnected with a 115 kV upland transmission line system within two parallel below-grade landfall transition vaults that will have interior dimensions of 7'0"W x 34'0"L x 7'6"H, containing one circuit each. The proposed upland cables will be jointed to the submarine cables at the landfall in Yarmouth. The upland transmission line system will utilize 12 single-conductor 115 kV cables each with copper conductor, XLPE insulation, copper wire metallic shielding, aluminum/polymer laminate moisture barrier and an outer polyethylene sheath. The metallic shields of the cables will be cross-bonded to minimize the cable losses and to limit induced voltages in the shields. See Figure 4-11.

The 12 cables will be segregated into two circuits, each composed of two cables per phase. The cables will run in a concrete encased ductbank. The conductor cross section will be 800 mm2 (approximately 1,600 kcmil) as shown in Figure 4-11.

The upland transmission line will enter the NSTAR Electric ROW and make the physical connection to the Barnstable Switching Station by continuing with two new underground transmission lines in the existing NSTAR Electric ROW approximately 1.9 miles (3.1 km) in length and running from the point where the new upland transmission line intersects the existing ROW in Yarmouth to the Barnstable Switching Station. The two transmission lines together would be comprised of 12 (2 circuits x 2 conductor/phase x 3 phases) cables 800 mm2 (approximately 1,600 kcmil) in a cross sectional area. A third bay would be added at the Barnstable Switching Station to allow for the installation of three new circuit breakers and two banks of shunt reactors as shown in Figure 4-12.

4.2.3 Ancillary Structures

The duct system will consist of a single ductbank, approximately 5'8"W by 2'H in size with a total of sixteen (16) 6-inch PVC ducts encased within a concrete envelope. The ductbank will be constructed within a trench beneath existing roadway corridors along the majority of the route. Twelve (12) of the 16 ducts will be occupied with the upland transmission lines, two ducts will contain fiber optic lines for protective relaying and communications, and two vacant ducts will be reserved for future use as spares. Figure 4-13 shows a typical cross section of the transmission line "eight over eight" ductbank, which will also be utilized within the NSTAR Electric ROW. Figure 4-14 shows a typical cross section of the transmission line "four over four" ductbank, which will be utilized to transition from underground vaults to the "eight over eight" ductbank.

In addition to the landfall transition vault at the landfall site, the proposed transmission facility will include approximately 15 underground vaults along the public roadway layout portion of the proposed route and approximately nine underground vaults within NSTAR Electric's ROW. The vaults will include upland transition vaults which are required at locations utilizing trenchless techniques as discussed in section 4.3.6 and typical splice vaults. All vault locations will include two parallel vaults constructed of reinforced concrete, approximately 8 inches thick. The interior dimensions of the upland transition vaults and the splice vaults will be 7'0"W x 33'6"L x 7'6"H. The underground vaults will be located along the route as required based on cable reel capacities and to keep cable pulling tensions within manufacturer's specifications, generally at intervals between 500 to 1,700 feet (152.4 to 518 meters). The underground vaults will accommodate cable splicing and cross-bonding of cable metallic sheaths. Please refer to Figures 4-15 through 4-17 for typical cross-sections of the three vaults.

4.3 Construction

The anticipated schedule for the entire project, if financing is achieved in the first quarter of 2005, is as follows: (1) during the winter of 2005-2006 the upland ductbanks, landfall transition and the temporary cofferdam will be installed; (2) during the first two quarters of 2006 the ESP, the submarine 115 kV cables, and the upland 115 kV cables will be installed; and (3) beginning the third quarter of 2006, the WTGs, the inner-array cables and the scour mats will be erected and installed.

4.3.1 Wind Turbine Generator Installation

Installation of the WTGs will comprise four activities: 1) installation of the foundation monopiles; 2) erection of the wind turbine generator; 3) installation of the inner-array cables and 4) installation of the scour protection mats.

Major construction activities will be supported by onshore facilities, which are anticipated to be located in Quonset, Rhode Island. Material and equipment will be staged onshore, at existing port facilities in Quonset, RI (or some similar location), and then loaded onto various vessels for transportation to the offshore site, and ultimately installation. Construction personnel will be ferried by boat and / or helicopter depending upon weather conditions and other factors. Once loaded, the vessels will travel from Quonset through Narragansett Bay to Rhode Island Sound to Vineyard Sound, North of Martha's Vineyard to the Main Channel, a distance of about 55 nautical miles.

The Applicant has identified an existing, underutilized, industrial port facility in Quonset, RI as having the attributes required for staging an offshore construction project of the magnitude of the Cape Wind Project. The Quonset Davisville Port & Commerce Park is located on Narragansett Bay in the town of North Kingstown, Rhode Island and is owned and controlled by the Rhode Island Economic Development Corporation (RIEDC). This site is a portion of what once was a much larger government facility known as the U.S. Naval Reservation–Quonset Point, part of which is still actively utilized as a civilian airport and base for an Air National Guard Reserve squadron.

The Quonset Davisville Port & Commerce Park is an active marine industrial site that houses several industrial businesses such as General Dynamics (shipbuilding) and Senesco (marine construction). Following the downsizing of the US Naval Reservation – Quonset Point, the park was created in order to develop prime industrial sites, create job opportunities and to improve the economic conditions throughout the region. The staging of the Cape Wind project from the Quonset Davisville Port & Commerce Park is consistent with the park's stated purpose.

The entire park consists of approximately 3,150 acres, of which 817 acres have been sold for such uses as industrial, offices, and transportation/utility (railroad and highways). Another 463 acres have current leases, 605 acres are used for a civilian airport (Quonset State Airport - OQU) operated by the State of Rhode Island, approximately 600 acres are designated open space, about 200 acres are utilized for recreation including a golf course, and the remaining 465 acres are vacant, open land available for industrial and commercial activities.

The site has deep-water capacity (30' depth) and two piers that are 1,200 feet in length and capable of servicing the largest of ships, (specify more). One of the piers (Pier 1) is currently leased by Norad as an automobile unloading and transfer operation. The other pier (Pier 2) has intermittent use as a staging area for the Rhode Island Department of Transportation bridgework. Pier 2 will become available in the near future; however, based on timing, either pier may be available for lease.

The Applicant has been actively pursuing the use of Pier 2 because it has a load bearing capacity of over 1,000 pounds per square foot and is 1,200 feet long by 650 feet wide. This Pier would be used for the receiving, storing and assembly of the large turbine parts such as the monopiles, towers, nacelles, transition pieces, hubs, rotors and blades. The Applicant and RIEDC have started discussions pertaining to leasing all or part of Pier 2 and the land contiguous to it which consists of approximately 33.5 acres zoned for industrial or commercial activity. Additional land is also available within the park, approximately 3,000 feet away accessible by a public road approximately 40 feet in width. These satellite parcels consist of approximately 25 plus acres and could be used for other components of the wind turbines and associated infrastructure if needed. One of the parcels has two large buildings which were utilized by the US Navy Construction Battalion (Seabees) during the 1940's, 50's and 60.s, which may be capable of handling certain aspects of the project such as blade manufacturing.

All portions of the Quonset Davisville Port & Commerce Park that the Applicant has identified as being appropriate for the staging of the Cape Wind Project, including the satellite parcels, were formerly active industrial / commercial sites with all of the necessary utility infrastructure in place (such as electric service, water, sewer drainage and communications). Some modifications to the buildings and roadways may be required to accommodate the specialized equipment and wind turbine components. The deep-water piers are adequate to accommodate all anticipated construction vessels and are not expected to require any additional dredging or modification.

Monopile installation will begin by loading individual monopiles onto a barge, six to ten at a time, for transport to the work site. Depending upon the actual barge utilized and other logistical requirements, the Applicant is anticipating approximately 20 trips to move monopiles to the work site.

A jack-up barge with a crane will be utilized for the actual installation of the monopiles. The jack-up barge will have four legs with pads of about four meters square (approximately 172 square feet). The crane will lift the monopiles from the transport barge and place them into position. The monopiles will be installed into the seabed by means of pile driving ram or vibratory hammer and to an approximate depth of 85 feet (26 meters) into the seabed. This will be repeated at all WTG locations. Only two pieces of pile driving equipment will be present within the Project area at any one time, and they are unlikely to be operating simultaneously. Minimal disturbance of sand and sediment will take place by pile driving activities. The piles are hollow and will contain bottom material that is displaced in the pile.

Length of monopile, insertion distance and finished elevation will vary by individual location due to water depth and structural and geotechnical parameters. Monopiles to be installed will range in length from approximately 110 feet (33.5 meters) for those installed in the shallowest locations to more than 160 feet (49 meters) at the deepest sites. The anticipated duration of installing all of the monopiles from start to finish is expected to be approximately eight months plus any delays due to weather.

Installation of the WTG itself will be from a specialized vessel configured specifically for this purpose. See Figure 4-18 for drawings of a typical vessel. Work vessels for the Project will comply with applicable mandatory ballast water management practices established by the USCG in order to avoid the inadvertent transport of invasive species.

This vessel would be loaded at Quonset, RI with the necessary components to erect six to eight WTGs. Components include transition pieces to place on the monopiles, towers, nacelles, hubs and blades.

The vessel would transit from Quonset to the work site as described above and locate itself adjacent to one of the previously installed monopiles. A jacking system will then stabilize the vessel in the correct location. Depending on the actual circumstance, four or six jacking legs will raise the vessel to a suitable working elevation. A transition piece unique to the specific WTG, is placed by the vessel's crane onto the monopile, leveled and set at the precise elevation for the tower. This piece will be a fabricated steel structure complete with a turbine tower flange, "J" tubes for cable connections and a boat landing device. The transition piece is then grouted in place to the foundation monopile using a product such as Ducorit® D4 by Densit. The crane will then place the lower half of the tower onto the deck of the transition piece. Once this piece is secured, the upper tower section is raised and bolted to the lower half. In order, the nacelle, hub and blades are raised to the top of the tower and secured. Several of these components may be pre-assembled prior to final installation. This process is anticipated to take approximately 30 to 40 hours to cycle through one complete WTG and would be repeated for each of the 130 WTG locations. Including the twenty or so trips from Quonset to Horseshoe Shoal, this process will take approximately nine months plus any delays due to weather. The installation of the WTG will overlap with the installation of the monopiles.

As the monopiles and WTGs are completed, the submarine inner-array cables will be laid in order to connect the string of wind turbines (up to 10 WTGs), and then the seabed scour control system will be installed on the seabed around each monopile. This will consist of a set of six scour-control mats arranged to surround the monopile. Each mat is 16.5 feet by 8.2 feet (5 meters by 2.5 meters) with eight anchors which securely tie to the seabed. See Figure 4-19 for the arrangement of the mats. For a complete installation procedure, see Appendix 4.0-A. It is anticipated that the process of completing one string of WTGs (10 WTGs with associated inner-array cable and scour mats) will take up to approximately one month.

The transition piece of the WTGs, which will be located within the submerged/splash zone, will be coated with a product equal or similar to Dupont Interzone 954. The portions of the structural steel and steel surfaces not directly exposed to seawater, such as the tower, will be coated with an epoxy-polyamide. The addition of a cathodic protection system utilizing a galvanic (sacrificial) aluminum anode system will be utilized.

4.3.2 Electric Service Platform Installation

The ESP design is based on a piled jacket/template design with a superstructure mounting on top. The platform jacket and superstructure will be fully fabricated on shore and delivered to the work site by barges.

The jacket will be removed from the barge by lifting with a crane mounted on a separate derrick barge. The jacket assembly will then be sunk and leveled in preparation for piling. The six piles will then be driven through the pile sleeves to the design tip elevation of approximately 150 feet (46 meters). The piles will be vibrated and hammered as required.

The superstructure installation will consist of lifting from the transport barge onto the jacket. It will then be connected to the jacket in accordance with the detail design requirements. After attachment, additional components including ladders, heliport and vessel docking structure will be lifted from a barge and set onto the superstructure for attachment. The installation of the ESP is anticipated to take approximately one month to complete.

After the ESP is fully constructed, installation of the inner-array cables and the high voltage transmission cables will be installed. These cables will be routed through J-tubes located on the outside of the support jackets. Once the inner-array cables are connected to the ESP, the scour mats will be installed to the ESP piles utilizing a similar design as the WTG foundations.

The ESP will be coated with a similar paint system as the WTG. The addition of a cathodic protection system utilizing a galvanic (sacrificial) aluminum anode system will be utilized.

4.3.3 33 kV Inner-array Submarine Transmission Cable System Installation

The 33 kV cable will be transported to Quonset Point, RI from the Pirelli Cable factory in a special cable transport vessel. The cable will be transferred onto the cable installation barge. The linear cable machines on-board the barge will pull the cables from coils on the transport vessel onto the barge, and into prefabricated tubs.

The installation barge and auxiliary barge mobilizations will all take place in Quonset, RI.

After the cable has been transferred the installation barge will be towed to the Horseshoe Shoal site. This will be repeated as required to deliver and install all the required cable.

The proposed method of installation of the submarine cable is by the Hydroplow embedment process, commonly referred to as jet plowing. This method involves the use of a positioned cable barge and a towed hydraulically-powered jet plow device that simultaneously lays and embeds the submarine cable in one continuous trench from WTG to WTG and then to the ESP. The barge will propel itself along the route with the forward winches, and the other moorings holding the alignment during the installation. The six point mooring system will allow the support tug to move anchors while the installation and burial proceeds uninterrupted on a 24-hour basis.

When the barge nears the ESP, the barge spuds will be lowered to secure the barge in place for the final end float and pull-in operation. The cable will be pulled into the J-tube and terminated at the switchgear.

4.3.4 115 kV Submarine Transmission Cable System Installation

The submarine cable system consists of the two 115 kV solid dielectric AC submarine transmission circuits (two (2) three-conductor cable systems per trench equals one circuit, for a total of 4 cables), Figure 4-20. The two circuits of interconnecting transmission lines linking the ESP to the landfall location will be embedded by jet plow approximately six feet below the sea floor, with approximately 20 feet (6.1 meters) of horizontal separation between circuits.

The 115 kV cable will be transported from the manufacturer to Quonset Point, RI, the mobilization point. The cable will be transferred to the installation barge by pulling via the linear cable machines mounted on board the barge. After the cable has been transferred, the installation barge will be towed to the Lewis Bay installation site.

The day after the completion of the burial equipment trials, the installation barge will be moved to Lewis Bay and set offshore of the New Hampshire Avenue landfall (described in Section 4.3.5 below). A second smaller barge, capable of operating in shallow water, will also be used in conjunction with the larger installation barge.

Prior to pulling the cable ashore and to the sea-land transition vault, the Hydroplow will be set up in the pre-excavation pit located at the offshore end of the drilled conduit. The cable will then be floated from the barge with assistance of small support vessels. The cable end will be securely anchored in place after being pulled through the Hydroplow and into the conduit and secured beyond the transition vault.

From the HDD exit point, the cable is embedded across the shallows by means of towing the Hydroplow along the cable route from the smaller barge's winch. The cable and jet hose will be supported by cable floats to maintain control of cable slack and the amount of hose out. The cables between the jet plow start point and the transition vault will be inside the HDPE conduits installed during the horizontal directional drill.

When the cable embedment has proceeded into deeper water and nears the barge, the Hydroplow setback will be secured approximately 20-30 feet (6.1-9.1 meters) behind the stern chute, the barge will lift its spuds and begin winching along the cable route, with the six point mooring system towing the Hydroplow and feeding cable off the barge and into the plow funnel as it moves along the route at a rate equal to the barge movement. This will be repeated for the second circuit.

The barge will propel itself along the route with the forward winches, and the other moorings holding the alignment of the route. The six point mooring system allows the support tug to move anchors while the installation and burial proceeds uninterrupted on a 24-hour basis.

When the barge nears the ESP, the barge spuds will be lowered to secure the barge in place for the final end float and pull-in operation. The cable will be pulled into the J-tube and terminated at the switchgear.

- The following is a list of the primary installation equipment:
- Hydroplow cable burial machine designed for six-foot burial depth;
- Installation Barge 100x400x24;
- Anchor handling tugs - two 3000hp twin screw (will be with the barge for the duration of the installation;
- Six-point mooring system with two 60-inch spuds. The mooring system will consist of 3 double winches, plus another double drum winch for controlling the two spuds. Each winch drum will contain approximately 2,000 feet (610 meters) of 1 1/8" mooring cable and have an anchor attached. Mid-line buoys will be attached to minimize anchor cable scour. Pendant wire with 58-inch steel ball buoys will be attached to anchors for deployment and quick recovery;
- Cable burial support system including pumps, and Hydroplow accessories.
- Cable laying support system including cable machines, chute, tubs and complete diving operations center to support divers;
- Auxiliary trencher pulling barge - a small barge of 40 x 100 feet (12.2 x 30.5 meters) outfitted with spuds; and
- Auxiliary vessels - there will be a crew boat, two inflatable boats, and several skiffs.

This process will be conducted twice (once for each circuit). Jet plow embedment methods for submarine cable installations are considered to be the most effective and least environmentally damaging when compared to traditional mechanical dredging and trenching operations. This method of laying and burying the cables simultaneously ensures the placement of the submarine cable system at the target burial depth with minimum bottom disturbance and with the fluidized sediment settling back into the trench. For these reasons it is the installation methodology that appears to be preferred by state and federal regulatory agencies based on review of past precedent setting projects.

Jet plow equipment uses pressurized sea water from water pump systems on board the cable vessel to fluidize sediments. The jet plow device is typically fitted with hydraulic pressure nozzles that create a direct downward and backward "swept flow" force inside the trench. This provides a down and back flow of re-suspended sediments within the trench, thereby "fluidizing" the in situ sediment column as it progresses along the predetermined submarine cable route such that the submarine cable settles into the trench under its own weight to the planned depth of burial. The jet plow's hydrodynamic forces do not work to produce an upward movement of sediment into the water column since the objective of this method is to maximize gravitational replacement of re-suspended sediments within the trench to bury or "embed" the cable system as it progresses along its route. The pre-determined deployment depth of the jetting blade controls the cable burial depth.

The cable-laying barge is specifically designed for installations of submarine cable. It is used for both transport and installation. The submarine cable is installed in continuous lengths delivered from the cable factory and loaded directly onto a revolving turntable on the vessel. The cable system location and burial depth will be recorded during installation for use in the preparation of as-built location plans. This information will be forwarded to appropriate agencies and organizations as required for inclusion on future navigation charts.

A skid/pontoon-mounted jet plow, towed by the cable-laying barge, is proposed for the Project's submarine installation. This jet plow has no propulsion system of its own. Instead, it depends on the cable vessel for propulsion. For burial, the cable barge tows the jet plow device at a safe distance as the laying/burial operation progresses. The cable system is deployed from the vessel to the funnel of the jet plow device. The jet plow blade is lowered onto the seabed, pump systems are initiated, and the jet plow progresses along the pre-selected submarine cable route with the simultaneous lay and burial operation, creating a trench approximately 4 to 6 feet (1.2 to 1.8 meters) wide (top width) to a depth of 8 feet (2.4 meters) below the present bottom into which the cable system settles through its own weight. The jet plow device is equipped with horizontal and vertical positioning equipment that records the laying and burial conditions, position, and burial depth. The pontoons can be made buoyant to serve different installation needs.

The geometry of the trench is typically described as trapezoidal with the trench width gradually narrowing with depth. Temporarily re-suspended in situ sediments are largely contained within the limits of the trench wall, with only a minor percentage of the re-suspended sediment traveling outside of the trench. Any re-suspended sediments that leave the trench tend to settle out quickly in areas immediately flanking the trench depending upon the sediment grain-size, composition, and hydraulic jetting forces imposed on the sediment column necessary to achieve desired burial depths (see Section 5.2).

It is anticipated that, to install each transmission line circuit to the required depth providing a minimum of six feet of cover in the sediments that are generally found along the proposed submarine transmission line route into Lewis Bay, the jet plow tool will fluidize a pathway approximately four to six feet wide at the seabed and eight feet deep. This interconnection will involve the installation of approximately 12.2 circuit miles (19.6 km) (of which 6.6 miles (10.6 km) are within Massachusetts' waters) of transmission cable for each of the two circuits. The installation of the submarine transmission line via jet plow embedment is anticipated to take approximately two to four weeks to complete. As the jet plow progresses along the route, the water pressure at the jet plow nozzles will be adjusted as sediment types and/or densities change to achieve the required minimum burial depth of 6 feet. In the unlikely event that the minimum burial depth of 6 feet below present bottom is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes will be utilized to achieve the required depth.

4.3.5 Landfall Transition Installation

The transition of the interconnecting 115 kV submarine transmission lines from water to land will be accomplished through the use of HDD methodology in order to minimize disturbance within the intertidal zone and near shore area. HDD would be staged at the upland landfall area and involve the drilling of the boreholes from land toward the offshore exit point. Conduits would then be installed the length of the boreholes and the transmission line would be pulled through the conduits from the seaward end toward the land. A transition manhole/transmission line splicing vault would be installed using conventional excavation equipment (backhoe) at the upland transition point where the submarine and land transmission lines would be connected, Figure 4-21.

There will be four 18-inch High Density Polyethylene (HDPE) conduit pipes (one for each three-conductor 115 kV cable and fiber optic cable set) installed to reach from the onshore transition vaults to beyond the mean low water level. The offshore end will terminate in a pre-excavated pit where the jet plow cable burial machine will start. The four conduits will have an approximately 10 foot (3 meter) separation within the pre-excavation area. The four boreholes will be approximately 200 feet (61 meters) long (borehole diameters will be slightly larger than the conduit diameter to allow the conduit to be inserted in the borehole), Figure 4-21.

A drill rig will be set up onshore behind a bentonite pit where a 40-foot (12.1 meter) length of drill pipe will be set in place to begin the horizontal drilling. A bentonite and freshwater slurry will then fill the pit in which the bentonite forms a hard shell lining of the tunnel wall during the drilling process. After each 40 feet (12.1 meter) of drill pipe installation, an additional length of drill pipe is added. To minimize the release of the bentonite drilling fluid into Lewis Bay, freshwater will be used as a drilling fluid to the extent practicable prior to the drill bit emerging in the pre-excavated pit. This will be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. When the drill bit emerges in the pre-excavated pit, the bit is replaced with a series of reamers to widen the borehole followed by a pulling head on the end of pipe and then the drill pipe is used to pull back the conduit into the bored hole from the offshore end. As with the drill process, freshwater will be utilized to the maximum extent practicable as the reaming process nears the pre-excavated pit.

The HDD and HDPE conduit installation process involves drilling a pilot hole by a directionally guided boring rig, followed by reaming to achieve the desired borehole dimension. After the borehole has been constructed, 18-inch (45.7 cm) diameter HDPE pipe will be installed in each borehole to serve as protection for the submarine cable system. Smaller conduits with pulling wires will be placed inside the 18-inch (45.7 cm) diameter HDPE pipe to house the submarine cable system. Once the internal cable conduits have been inserted into the 18-inch (45.7 cm) HDPE conduit, a clay/bentonite medium will be injected into the conduit system to fill the void between the cable conduits and the 18-inch (45.7 cm) pipe. The conduits will be sealed at both ends until the submarine cable system is ready to be pulled through the conduit. After submarine cable system installation, the conduits will then be permanently sealed at each end to complete the installation process.

The HDD construction process will involve the use of bentonite drilling fluids in a mineral water slurry in order to transport drill cuttings to the surface for recycling, aid in stabilization of the in situ sediment drilling formations, and to provide lubrication for the HDD drill string and down-hole assemblies. This drilling fluid is composed of a carrier fluid and solids. The selected carrier fluid for this drilled crossing will consist of water (approximately 95%) and inorganic bentonite clay (approximately 5%).

The HDD operation will include an upland based HDD drilling rig system, drilling fluid recirculation systems, residuals management systems, and associated support equipment. HDD drilling material handling equipment will be located on New Hampshire Avenue. Drilling will take place from the upland to Lewis Bay. Excavated soils will be temporarily stored near the HDD drill rig during construction, and will then be reused onsite or removed and disposed of as required.

To further facilitate the HDD operation, a temporary cofferdam will be constructed at the end of the boreholes. The cofferdam will be approximately 65 feet (19.8 meters) wide and 45 feet (13.7 meters) long and will be open at the seaward end to allow for manipulation of the HDD conduits. The area enclosed by the cofferdam will be approximately 2,925 square feet (271.7 square meters). The cofferdam will be constructed using steel sheet piles driven from a barge-mounted crane. The top of the sheet piles will be cut off approximately 2 feet (0.61 meters) above mean high water. This will serve to contain any turbidity associated with the dredging and subsequent jet plow embedment operations and to provide a visual reference to its location for mariners. While the cofferdams will be located outside of areas normally subject to vessel traffic, the location of the cofferdam will be appropriately marked to warn vessels of the temporary cofferdam's presence.

The area inside the cofferdam will be excavated to expose the seaward end of the borehole. Sediment inside the cofferdam will be excavated to expose the area where the HDD borehole will end at an elevation of approximately -10 feet (-3 meters) MLLW, with a 1 foot (0.3 meter) allowable overdredge. A 20 foot (6.1 meters) long level area will be created at the closed end of the cofferdam at this elevation. From that point, the bottom of the excavated area will be sloped at 4H:1V until it meets the existing seafloor bottom contour. Approximately 840 cubic yards (642.2 cubic meters) of sediment will be excavated from the cofferdam. The excavated material will be disposed of at an approved upland disposal location. No removal of sediment outside of the cofferdam will be required.

The cofferdam will help to facilitate threading of the submarine cable system through the 18-inch (45.7 cm) diameter HDPE pipes placed in the horizontal directional drilled boreholes. This temporary cofferdam will be installed prior to the beginning of the HDD borehole construction, and will remain in place until jet plow embedment installation of the submarine cable system is complete.

The length of submarine cable located within the temporary cofferdam will be placed in cast iron sleeves to protect the submarine cable system from accidental damage (such as an inadvertent anchor drop) until the excavated pit fills in naturally. A slight depression of the seabed surface may result if the natural movement of sediment is not sufficient to completely fill in the excavated pit naturally.

The HDD operations will be conducted to minimize or avoid impacts to water quality in Lewis Bay. The upland HDD operation will be a self-contained system combined with a drilling fluid re-circulation system. This re-circulation system will recycle drilling fluids and contain and process drilling returns for offsite disposal to minimize excess fluids disposal and residual returns. None of these materials will be directly discharged or released to marine or tidal waters in Lewis Bay.

The HDD operation will be designed to include a drilling fluid fracture or overburden breakout monitoring program to minimize the potential of drilling fluid breakout into waters of Lewis Bay. It is expected that the HDD conduit systems will be drilled through sediment overburden at the landfall location. However, it is anticipated that drilling depths in the overburden will be sufficiently deep to avoid pressure-induced breakout of drilling fluids through the seafloor bottom based primarily on estimates of overburden thickness and porosity. Nevertheless, a visual and operational monitoring program will be implemented during the HDD operation to detect a fluid loss. This monitoring includes:

- visual monitoring of surface waters in the adjacent Lewis Bay by drilling operation monitoring personnel on a daily basis to observe potential drilling fluid breakout points;
- drilling fluid volume monitoring by technicians on a daily basis throughout the drilling and reaming operations for each HDD conduit system;
- development and implementation of a fluid loss response plan and protocol by the drill operator in the event that a fluid loss occurs. These response plans include drill stem adjustments, injection of loss circulation additives such as Benseal that can be mixed in with drilling fluids at the mud tanks, and other mitigation measures as appropriate; and
- use of appropriate bentonite drilling fluids that will gel or coagulate upon contact with sea water.

In the unlikely event of an unexpected drilling fluid release, the bentonite fluid density and composition will cause it to remain as a cohesive mass on the seafloor in a localized slurry pile similar to the consistency of gelatin. This cohesive mass can be quickly cleaned up and removed by divers and appropriate diver-operated vacuum equipment.

As described above, a bentonite and freshwater slurry will be used as the drilling fluid as the drilling and reaming operations approach the exit point in the pre-excavated pit. The drilling fluid will consist of water (approximately 95%) and an inorganic, bentonite clay (approximately 5%). The bentonite clay is a naturally occurring hydrated aluminosilicate composed of sodium, calcium, magnesium, and iron. It is likely that some residual volume of bentonite slurry will be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to contain any bentonite slurry that may be released. Prior to drill exit and while the potential for bentonite release exists, diver teams will install a water-filled temporary dam around the exit point to act as an underwater "silt fence". This dam will contain the bentonite fluid as it escapes and sinks to the bottom of the pre-excavated pit to allow easy clean-up using high-capacity vacuum systems.

Each of the two landfall transition vaults will be approximately 8 feet (2.4 meters) wide by 35 feet (10.7 meters) long (outside dimensions), Figures 4-15 and 4-21. The submarine transmission lines will be spliced to the upland transmission lines within these transition vaults. The transition vault will contain two 38-inch (96.5 cm) manholes for access and be installed approximately with its bottom ten feet below grade. The submarine transmission lines will enter through the four 18-inch (45.7 cm) HDPE conduits and the upland transmission lines will exit the landfall transition vault to the ductbank system through 6-inch diameter PVC conduits. There will be a total of 16 PVC conduits encased within concrete: 12 transmission line conduits, two conduits for 96-fiber fiber optic cables for telecommunications, SCADA and protective relaying, and two spare conduits for the upland transmission line, as shown in Figures 4-13 and 4-14.

It is anticipated that the installation of the borehole and conduit by HDD techniques will take approximately two to four weeks.

Upon completion of the installation of the conduit pipes and submarine cable system, the HDD equipment will be removed and New Hampshire Avenue will be restored to its pre-construction grades and conditions. Standard stormwater erosion and sedimentation controls will be installed on the site prior to the initiation of construction activities, and will be inspected and maintained throughout construction operations. Once construction is completed, all equipment and construction materials will be removed from the site and the area will be returned to its original condition.

The transition of the interconnecting 115 kV submarine transmission lines from water to land will be accomplished through the use of standard construction techniques and jet plow embedment. The Hydroplow will be utilized from approximately 90 feet (27.4 meters) seaward of the existing concrete wall at the end of New Hampshire Avenue.

4.3.6 Upland Transmission Line Installation

Construction of the upland transmission line will occur in two phases. The first phase will consist of installing the ductbanks, conduits, and vaults. The second phase will consist of the installation of the upland 115 kV transmission lines, including splices and terminations. Phase I is anticipated to take approximately five months to complete. Phase II is also anticipated to take approximately five months. The installation of the upland components will occur outside of the summer tourist season.

The upland transmission line installation, from the transition vault at the landfall to the Barnstable Switching Station, will involve installation of the transmission line in the underground splice vaults and ductbanks within existing public ways and ROWs. Most excavation will be performed with standard machinery, including excavators and backhoes, with the exception of four railroad/state highway intersection crossings which will be accomplished using trenchless techniques. All work will be performed in accordance with local, state, and/or federal safety standards.

Underground upland transition vaults will be constructed approximately every 500-1,700 feet (152.4-518 meters) (the approximate length of transmission line that can be effectively transported by truck and pulled within manufacturer's tension specifications). These vaults will accommodate cable splicing and cross-bonding of cable metallic sheaths. Each of the two parallel underground upland splice vaults utilized at each splice location will be approximately 8 feet (2.4 meters) wide by 35 feet (10.7 meters) long (outside dimensions), Figure 4-17. The underground upland transition vaults will be placed approximately nine to ten feet deep (bottom of vault) and each underground vault will contain two 38-inch (96.5 cm) manholes. Please refer to Figure 4-16 for more details.

The transmission lines will be installed within a ductbank consisting of PVC conduits for the transmission lines spaced approximately eight inches apart (on center) encased in unreinforced concrete (minimum of 2,000 psi) which is backfilled with native material or suitable backfill to original grade. In addition, there will be two copper ground wires placed within the encasement as shown in Figure 4-13. The trench opening will be a minimum of ten feet wide within the roadways and a minimum of eight feet wide within the ROW and supported by temporary trench boxes. The ductbank will be approximately 2'H x 5'8"W. Burial depth to the top of the ductbank will be a minimum of 56 inches (142.2 cm) within the roadways to allow passage under existing water and gas lines and a minimum of 24 inches (61 cm) within the NSTAR Electric ROW (with the exception of road-crossings along the ROW where the burial depth will revert to 56 inches (142.2 cm)). A warning tape will be placed approximately one foot below the surface of the trench opening for dig-in protection. There will be a total of 16 six-inch (15.2 cm) diameter PVC conduits inside the concrete ductbank. The ductbank will be installed in a single trench (see Figure 4-13.)

Excavated soil from the trench and vaults will be temporarily stored adjacent to the worksite or transported off-site if on-site storage is not possible. Where soil is stored at the site, it will be stabilized with erosion and sedimentation controls. Following the completion of the installation of the transmission line, the excavation will be backfilled and repaved. Stormwater erosion and sedimentation controls will be in place prior to the initiation of construction activities. Once construction is completed, all equipment and construction debris will be removed from the site and the area will be returned to its original condition.

To minimize the potential for erosion during construction, mitigation measures, such as hay bales and silt fences will be placed as appropriate around disturbed areas and any stockpiled soils. Prior to commencing construction activities, erosion control devices will be installed between the work areas and downslope water bodies and wetlands to reduce the risk of soil erosion and siltation. Erosion control measures will also be installed downslope of any temporarily stockpiled soils in the vicinity of waterbodies and wetlands. These mitigation measures will be fully described in an Erosion and Sedimentation Control and Storm Water Management Plan, which will incorporate applicable best management practices (BMPs) for erosion control and stormwater management during construction. It is possible that dewatering of the excavated trench or vault locations close to the transition point will be required because of high groundwater. A dewatering plan will be prepared to address the procedures for handling of any water encountered during excavation.

Trenchless technologies will be employed in several areas along the upland cable route to cross heavily traveled state highway layouts and railroad beds and avoid the disturbances caused by standard construction methods. Trenchless technologies may include Horizontal Directional Drilling (HDD), Horizontal Boring or Pipe Jacking.

In all instances a starting pit will be excavated to initiate the advancement of a casing or carrier pipe. Four carrier pipes will be used to accommodate all the conduits from the duct bank. Depending on the method used the casing is advanced by drilling, boring or simply pushing the casing pipe through the soil. A receiving pit is also excavated at the receiving end to accept the casing or carrier pipe. The trenchless technology utilized will be selected on a case-by-case basis at each location and will depend on the distance required to advance the carrier pipe beyond the roadway or railroad in question, the nature of the soils at the location and the space available for mobilization and excavation of starting and receiving pits.

Following the installation of the carrier pipes, transition vaults will be installed to transition between the standard duct bank installation and the carrier pipes.

4.4 Operations and Maintenance Plan

The Operations and Maintenance (O&M) Plan will provide operations and maintenance support of all components of the Wind Park including the ESP, submarine transmission cables and wind park security.

A continuously manned, land-based Operations Center will be established to remotely monitor all aspects of the Wind Park's operations. It is anticipated that this Operations Center will be located in the Town of Yarmouth.

The maintenance program will include preventive and emergency maintenance functions including shore based predictive maintenance analysis of the WTG and ESP. The maintenance plan is based on utilizing two additional locations: one for the parts storage and larger maintenance supply vessels and the second being closer to the site for crew transport.

The maintenance operation will be based in New Bedford, Massachusetts and will also deploy several crew boats out of Falmouth, Massachusetts. The New Bedford facility will be located on Popes Island and will include dock space for two 65-foot (19.8 meter) maintenance vessels as well as a warehouse for parts and tool storage and crew parking. An off-site warehouse will also be utilized to increase parts storage.

The New Bedford facility will house tools, spare parts and maintenance materials, and will be organized to support the daily work assignments. These will be loaded into small containers and assigned to each of the work teams and loaded onto the maintenance vessel for deployment to the wind farm site. The maintenance vessel will then go to the WTG or ESP and offload the containers to the work crews.

Dock space will be rented in Falmouth Inner Harbor to provide space for two crew boats between 35 and 45 feet (10.7 and 13.7 meters) overall length and one smaller (20-25 foot (6.1-7.6 meter)) high-speed emergency response boat. The crew boats will bring work crews to Horseshoe Shoal where they will be transferred to the WTG, ESP or the larger maintenance vessels. The number of individuals that will normally be transported out of Falmouth on a daily basis will be nine plus the boat crew of two.

Maintenance Intervals

Based on both offshore and onshore WTG operational experience, five days per year per turbine has been established as anticipated maintenance intervals. These visits cover two days of planned or preventative maintenance, and three days of unplanned or forced outage emergency maintenance. The WTG design is based on a twenty year operating life and all components have been analyzed to meet this design criterion. Based on

130 WTGs, this is equivalent to 630 maintenance days. Based on 252 workdays per year (which adjusts for weather days and holidays) this results in 2.5 work teams or conservatively three teams being deployed. During these deployments the ESP will be included with the trips. Weather conditions will have an influence on the maintenance operations of the wind park. Scheduled outages for maintenance will be planned for summer months when winds are low and sea states are minimal. Experience has shown that wind speeds must be less than eight m/sec to gain safe access to the WTGs, although safe access with winds up to 12 m/sec is possible depending on direction and sea state. Based on these weather related concerns, the number of trips per day could be altered to take advantage of good weather.

It is anticipated that the uncovering of the submarine cables due to natural processes is unlikely due to the minimum 6-foot burial depth below present bottom and will be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the submarine cables will be reburied.

Number of Vessel Trips

Based on the above analysis the normal activity would include two vessel trips per working day (252 days/year), which would include one crew boat from Falmouth and the maintenance support vessel from New Bedford. In addition an occasional second round trip from Falmouth could take place in times of fair weather or for emergency service.

WTG Work Crew Deployment

The work crews will be transferred from the crew boat to the WTG by exiting the stern of the vessel. This operation will be performed only when the sea conditions are within the workable range of the crew and vessels.

ESP Service

The ESP will have a helicopter-landing platform in addition to the boat dock. This will allow for maintenance crews to be deployed to the ESP during periods when wind and wave conditions are unsuitable for boat transfers. The helicopter platform will also allow for emergency evacuation of any individuals who may become injured.

Submarine Cable Repair

The potential for a fault occurring during the operational lifetime of a buried cable system is minimal, based on industry experience. However, a cable repair plan will be formulated to cover the remote possibility of a fault occurring in the offshore submarine cable system. The focus would be to repair the cable quickly while minimizing or eliminating environmental and community impacts.

Should a cable failure occur, a mobilization and communication plan would be implemented. Once the location of the fault is identified, should the cable fault occur in the upland sections of the project, then typical trench, repair and backfill methods would be used and no formal fault plan required. Within the submarine portion of the Project, the procedures listed below are one way of repairing any cable fault. Communication with the appropriate people will take place at least 48 hours prior to repair and will include location, method, and date of work.

- Repair crews will mobilize the splice boat and fine tune the location of the fault;
- The splice boat will likely be a barge, equipped with water pumps, jetting devices, hoisting equipment and other tools typically used in repairs of cables;
- Expose the cable with hand-operated jet tools and cut the cable in the middle of the damaged area;
- Position the repair vessel above the cut cable, and raise one end;
- Cut off the damaged portion of the cable;
- Perform a cable splice between the retrieved cable and the spare cable onboard;
- Pay out cable and move to the other cable end, keeping a portion of the spare cable onboard;
- Retrieve the other cable end;
- Cut off the damaged portion of the cable;
- Perform a cable splice between the retrieved cable and spare cable onboard;
- Lower the second joint and position it on the sea bottom;
- Hand jet the repaired and exposed sections into the sea bottom and
- Demobilize the repair vessel.

4.5 Decommissioning

From the start of construction, a financial instrument will be in place to ensure that sufficient funds are available for removal of equipment and associated material as described above.

Decommissioning for the WTGs is essentially the reverse of the installation process. The first step would be to disconnect the WTG from the inner-array cable system and remove the cable from the WTG. In deconstructing the WTGs down to the transition piece, the blades, hub, nacelle and tower would come apart in the same manner that they were put together utilizing similar equipment. The parts would be brought to shore for reuse or recycling. With the exception of the fiberglass, virtually the entire WTG is recyclable. The monopile, with the transition piece, would be cut off at the mud line followed by the removal of the sediment within it to a suitable depth (approximately 6.5 feet (2 meters) below the level of the seabed). Once the sediments have been removed, the remaining monopile would be cut off at a depth of approximately 6.5 feet (2.0 meters) below the surface. The monopile would be placed on a barge and brought to shore for recycling. The scour protection would be recovered as individual mats, brought to the surface by a crane, placed on a barge and brought to shore for recycling or disposal.

Decommissioning for the ESP will be a reverse process of the construction activities and will commence when the 33 kV and 115 kV cables have been disconnected and removed from the ESP. The heliport, ladders and boat platform will be removed by cutting and placed on a barge. The superstructure will than be lifted onto a vessel and moved to port. The balance of the jacket structure will be cut from the piles and lifted out of the water for placement on barges. The piles will be cut below the sand line and removed.

During decommissioning, the submarine cables will be disconnected and pulled out of the J-tubes on both the WTG and the ESP, and the cables will be cut below the seafloor. The cables will then be reeled in after being water jetted free of the bottom sand. The reels will be transported to the staging area for further handling. It is expected that all metal from the cable will be reused via recycling.

The equipment used to remove the submarine cables will be similar to that used for installation (barge, attendant tugs and jet plow equipment).

Decommissioning of the landfall transition and the upland transmission line components would consist of leaving in place the HDD conduits as well as the conduits, ductbanks and underground vaults beneath the roadways and ROW. The submarine and upland cables would be removed as described above.

4.6 Solid and Hazardous Materials

4.6.1 WTG Fluid Containment

The WTG will utilize lubricating oil, cooling liquids, and grease, all of which will be located in the nacelle or hub. The WTG has been carefully configured to contain any fluid leakage and prevent overboard discharges. The primary WTG components and the fluids contained are explained as follows:

Hub - The hub houses the blade pitching system, which is controlled by electric motors and contains only grease to lubricate parts.

Main bed plate - Inside the main bed plate (located in the nacelle) is the oil conditioning system of the gearbox, main bearing and generator bearings. The fluid capacity of the gearbox and bearings is approximately 190 gallons. As part of the oil conditioning system an oil/water cooling system is also located in the main bedplate. In the event of leaking gear oil or a broken hose/pipe, the leaking oil will be guided through the manhole in the bottom of the bedplate and collected on the upper internal platform of the tower.

Tower - The upper internal platform is designed and sealed in such a way that it can withhold the total amount of gearbox and hydraulic fluid until it can be transferred to containers for safe disposal.

Fluids - The fluids utilized in the various systems include gear oil, mineral oil for the hydraulic system and a water glycol mix for the cooling system.

The possibility of leaks may occur in two different situations: (1) during service and maintenance and (2) during operation:

Service- During the servicing and maintenance of a WTG, a spill could happen during oil changes of hydraulic pump units or the gearbox oil conditioning system.
Operation failures- During WTG operation leakage may occur as the result of broken gear oil hoses/pipes, and / or broken coolant hoses/pipes. Gear oil leaks will be contained within the hub and main bed frame and/or tower as described above. Coolant leaks can occur on a number of locations within the nacelle and will be contained inside the nacelle fiberglass cover.

In order to minimize and mitigate any minor spill incidents, all service vessels will be equipped with oil spill handling equipment. In addition, waste collection systems will be installed on board each WTG. The waste collection system is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste will be separated (i.e., used oil, coolant liquids, filters, paper/rags, etc.) for correct disposal once the containers are off-loaded at the dock.

4.6.2 ESP Fluid Containment

The ESP will have small amounts of lubricating oil, greases and coolants in pumps, fans, air compressors, emergency generators and miscellaneous equipment plus diesel fuel. The ESP will also have four oil-cooled step up transformers.

The primary systems and fluid contained are as follows:

- **Main Transformer** - The four 110-megavolt amp (MVA) oil cooled main step up transformers will each have a capacity of approximately 10,000 gallons of dielectric cooling oil. The oil will be circulated through oil/air heat exchangers mounted on the roof of the platform. Each transformer will be mounted in a leak proof detention area that will have the capacity of holding 150% of the transformer oil. Each of the detention areas will be connected via valves to a storage tank that has the capacity to store 100% of the oil from all four transformers. The oil piping to the coolers and the coolers will be configured so that any failures will result in oil being drained to the detention area.
- **Emergency Diesel Generators** - The ESP will have two 750-kilovolt amp (KVA) emergency diesel generators to provide back up power in case of a power failure from shore. Each engine/generator will have several gallons of lubricating oil and glycol antifreeze coolant. The platform will have a 1,000-gallon diesel oil storage tank mounted in a detention basin.
- **Miscellaneous equipment** - Various pumps, fans, and an air compressor will be installed on the platform. They will be lubricated with either grease or oil in small quantities. The equipment will be installed in such a way that any leakage will be contained on the sealed deck of the ESP.

The ESP will have sealed, leak-proof decks, which will act as fluid containment. In addition, spill containment kits will be available near all equipment. The details of spill containment equipment and related spill control measures will be provided in Spill Prevention Control and Countermeasure (SPCC) Plan prior to operation of the facility.

4.7 Oil Spill Planning, Preparedness, and Response

The Minerals Management Service (MMS), a Bureau of U.S. Department of the Interior, is the Federal agency responsible for oversight of oil spill planning, preparedness, and response for select facilities in State and Federal waters. Specifically, the MMS requires that owners or operators of oil handling, storage, or transportation facilities that are located seaward of the coastline submit oil spill response plans (OSRPs) to MMS for approval prior to operations of that facility. Plans must be consistent with MMS regulations found at 30 CFR Part 254 and further explained in MMS Notice to Lessee No. 2002-G09 dated 01 October 2002.

Since the ESP and the WTGs will contain various amounts and types of oil, the Project will develop a SPCC plan which will meet the requirements of the OSRP in accordance with the above federal regulation. The OSRP must address all applicable components of the Project including the WTGs (Section 4.6.1) and the ESP (Section 4.6.2).

Additionally, the SPCC Plan/OSRP must describe the processes and procedures that will be used in the event of an oil spill from oil storage operations, and will include but not be limited to the following components:

- Designation of a trained qualified individual;

- Designation of a trained spill management team available on a 24-hour basis;
- Description of the spill-response operating team;
- A planned location for a spill-response operations center;
- Procedures for the early detection of a spill;
- Your procedures for spill notification;
- Oil Spill Response Organizations that the plan cites;
- Federal, State, and local regulatory agencies that you must notify when an oil spill occurs;
- Methods to monitor and predict spill movement;
- Methods to identify and prioritize the beaches, waterfowl, other marine and shoreline resources, and areas of special economic and environmental importance;
- Methods to protect beaches, waterfowl, other marine and shoreline resources, and areas of special economic or environmental importance;
- Methods to ensure that containment and recovery equipment as well as the response personnel are mobilized and deployed at the spill site;
- An inventory of spill-response materials and supplies, services, equipment, and response vessels available locally and regionally.

Under current regulations, the SPCC plan/OSRP must be reviewed every two years and must be updated, if necessary, as required by the regulation.

4.8 Security

A detailed security plan will be developed to monitor the Wind Park. This plan will include both video surveillance and visual observations by boat and helicopter. A manned operations center on land will be monitoring and maintaining communications to insure that the security of the equipment is not compromised. Access to the turbines will be through a hatch door on the platform that will be locked at all times. The ESP will utilize a similar locked access hatch system.

4.9 Safety

Based upon the findings presented below in Section 5.0 and the Navigational Risk Assessment (Appendix 5.12-B), it is not anticipated that the operation of the turbines will present any danger to any shipping, sailing, fishing or recreational boating activities in the area during normal operations. The components of the WTG are designed to last 20 years and have been tested and have had design certification and are equipped with a number of safety devices to ensure safe operation during their lifetime. These include the following:

- Vibration sensors, to detect if the turbine has excess vibration (caused for example by temporary icing of a rotor blade), will initiate a shutdown at preset levels;
- Other sensors to monitor, alarm and shut down the turbine when various parameter limits are exceeded;
- Independent fail safe brake mechanism to stop the turbine. The aerodynamic braking system is the main breaking system with mechanical breaking as a backup. The wind turbine will shut down at 55 mph;
- Dynamic and static testing of the blades to determine the ability to withstand fatigue from repeated bending; and
- Lightning protection system.

In the unlikely event of a catastrophic failure of a WTG component or structure the primary concern would be for the safety of the immediate area to avoid the creation of a hazard, and notification of the proper authorities (most notably the USCG). The second concern would be to plan for maintenance repair or replacement of the failed item. This will likely include an evaluation by the Project's insurance carrier, the turbine manufacturer (GE Wind), and Cape Wind maintenance personnel to collectively determine the root cause of the failure and to formulate a remedial action plan.

The vessels involved in the O&M will comply with all Coast Guard and other applicable regulations including proper licenses, inspection and safety equipment.

The WTGs and the ESP will be fitted with navigational aids to ensure air and water navigation safety.